

# TEMPORARY SYSTOLIC BLOOD PRESSURE ELEVATIONS AFTER NOREPINEPHRINE SYRINGE REPLACEMENT

Sterilized vs Aseptically Prepared Ready-to-Administer Syringes in Critically Ill Patients

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## Introduction

Syringe replacement during continuous norepinephrine infusion is a critical high-risk procedure in ICU patients and may cause hemodynamic instability.

- Previous literature primarily describes:
  - Blood pressure decreases due to interruption delays during syringe replacement
  - Time-to-target flow after syringe replacement
- No prior studies evaluated:
  - Early post-replacement peak flow rate (boluses) and the clinical impact in the first minutes after syringe replacement as part of the pump-syringe compatibility
  - Differences between sterilized (S-RTA-S) and aseptically prepared (A-RTA-S) ready-to-administer syringes

After switching to sterilized syringes, multiple ICU safety incidents were reported involving sudden systolic blood pressure elevations.



## Methods

- Primary Objective:
  - Quantify clinically relevant systolic blood pressure (SBP) elevations following norepinephrine 0.1 mg/mL, 50 mL syringe replacement using S-RTA-S vs A-RTA-S
- Secondary Objective:
  - Identify the root cause through laboratory flow rate analysis and pump compatibility testing while simulating syringe replacements

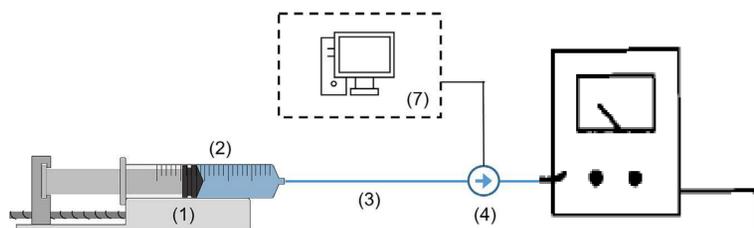


Figure 1. Syringe pump setup to simulate the clinical practice settings at the clinical physics department with the Rigel Multi-Flo infusion flow analyzer.

- Endpoints:
  - Clinically relevant systolic blood pressure elevations (SBP) of  $\geq 30$  mmHg
  - Peak flow rates after syringe replacement (S-RTA-S vs A-RTA-S)
  - Relevant parameters with significant impact on peak flow rate and SBP



## Study design

- Clinical systolic blood pressure analysis
- Laboratory flow measurement analysis
- Laboratory root cause analysis
- Tested variables: pump serial number, software version, catheter clamping, catheter diameter/rigidity and pump height relative to simulated bed height

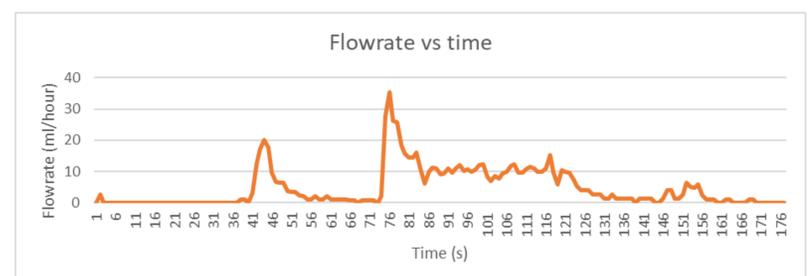


Figure 2: typical flow rate around S-RTA-S syringe replacement

- T = 0 - 41 s, replacement of syringe and initiation of flow rate measurements
- T = 42 s, the pump picks up the plunger followed by bolus 1
- T = 76 s, start of infusion and bolus 2; desired flow rate was set at 10 ml/hour
- T = 116 s, stop infusion
- T = 151 s, syringe remove



## Results

### Clinical Findings

Outcome	S-RTA-S	A-RTA-S	P value
Patients (n)	35	24	—
Clinically relevant SBP elevation $\geq 30$ mmHg	28.6%	0%	0.004
Replacements with SBP elevation	29.4%	0%	0.001
Mean SBP increase	+22.9 mmHg	+3.9 mmHg	—

Key finding: Nearly 1 in 3 patients experienced clinically relevant hypertension after S-RTA-S replacement.

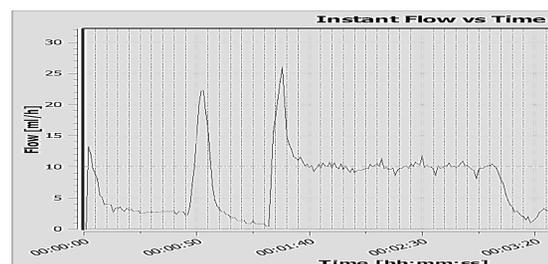
No events occurred with A-RTA-S.

### Laboratory Flow Measurements

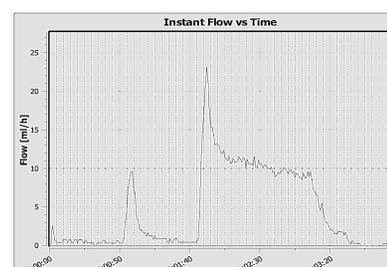
Flow Peak	S-RTA-S (mean $\pm$ SD)	A-RTA-S (mean $\pm$ SD)	P value
Bolus 1	13.7 $\pm$ 5.5 mL/h	1.8 $\pm$ 1.3 mL/h	0.003
Bolus 2	23.5 $\pm$ 3.5 mL/h	2.0 $\pm$ 3.4 mL/h	<0.001

S-RTA-S produced significantly higher peak flow boluses.

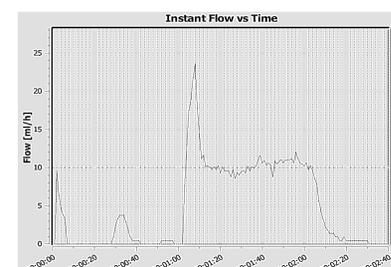
N=6 for each laboratory flow measurement test



Flow rate after S-RTA-S replacement. Significant higher boluses were observed compared with A-RTA-S syringe replacements. low rate was set at 10 ml/hr.



Flow rates after S-RTA-S replacement with the perfusor 40 cm above the bed height



Flow rates after S-RTA-S replacement with the perfusor on equal height to the patient

### Root Cause Analysis

#### Most Influential Parameter:

#### Pump Height Relative to Bed

- Pump +40 cm above bed  $\rightarrow$  significant Bolus 1
- Pump at equal height  $\rightarrow$  Bolus 1 significantly reduced
- Bolus 2 unaffected by height adjustment

#### Other Findings:

- Clamping eliminated Bolus 1 but caused extreme Bolus 2 (accumulated release)
- Larger flexible infusion lines increased Bolus 1

- Bolus 1 = Peak flow rate after plunger pickup
- Bolus 2 = Peak flow rate after infusion restart



## Conclusion

- Significant SBP elevations were observed in 29% of ICU patients after S-RTA-S replacement.
- Elevations were caused by two early flow boluses.
- Pump height significantly influences Bolus 1.
- Compatibility testing of syringe-pump combinations is essential.
- Early flow variability testing after syringe replacement must be included in validation protocols.
- Non-return valves were not tested in this analysis -> Future research

### KEY TAKE-HOME MESSAGE

When switching to sterilized ready-to-administer syringes, validate syringe-pump compatibility under real-world replacement conditions — especially for vasoactive drugs.

Small flow deviations can produce major hemodynamic consequences.



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